

Please type a plus sign (+) inside this box → ☐

PTO/SB/05 (4/98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

| | | |
|--|--|---|
| UTILITY PATENT APPLICATION TRANSMITTAL <small>(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))</small> | Attorney Docket No. | MYS-00-02-02 |
| | First Inventor or Application Identifier | Robert Mays, Jr. |
| | Title | Shared Multi-Channel Parallel Optical Interface |
| | Express Mail Label No. | EK 767460175US |

| | |
|--|--|
| APPLICATION ELEMENTS <small>See MPEP chapter 600 concerning utility patent application contents.</small> | ADDRESS TO: Assistant Commissioner for Patents Box Patent Application Washington, DC 20231 |
|--|--|

| | |
|---|---|
| 1. <input type="checkbox"/> * Fee Transmittal Form (e.g., PTO/SB/17) <small>(Submit an original and a duplicate for fee processing)</small> 2. <input checked="" type="checkbox"/> Specification [Total Pages 16] <small>(preferred arrangement set forth below)</small> - Descriptive title of the invention - Cross References to Related Applications - Statement Regarding Fed sponsored R & D - Reference to Microfiche Appendix - Background of the invention - Brief Summary of the invention - Brief Description of the Drawings (if filed) - Detailed Description - Claim(s) - Abstract of the Disclosure 3. <input checked="" type="checkbox"/> Drawing(s) (35 U.S.C. 113) [Total Sheets 4] 4. Oath or Declaration [Total Pages 3] a. <input checked="" type="checkbox"/> Newly executed (original or copy) b. <input type="checkbox"/> Copy from a prior application (37 C.F.R. § 1.63(d)) <small>(for continuation/divisional with Box 16 completed)</small> i. <input type="checkbox"/> DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b). | 5. <input type="checkbox"/> Microfiche Computer Program (Appendix) 6. Nucleotide and/or Amino Acid Sequence Submission <small>(if applicable, all necessary)</small> a. <input type="checkbox"/> Computer Readable Copy b. <input type="checkbox"/> Paper Copy (identical to computer copy) c. <input type="checkbox"/> Statement verifying identity of above copies |
|---|---|

| | |
|--|--|
| ACCOMPANYING APPLICATION PARTS | |
| 7. <input checked="" type="checkbox"/> Assignment Papers (cover sheet & document(s)) 37 C.F.R. § 3.73(b) Statement of Attorney 8. <input checked="" type="checkbox"/> (when there is an assignee) [3] 9. <input type="checkbox"/> English Translation Document (if applicable) 10. <input type="checkbox"/> Information Disclosure Statement (IDS)/PTO-1449 [] Copies of IDS Citations 11. <input type="checkbox"/> Preliminary Amendment 12. <input checked="" type="checkbox"/> Return Receipt Postcard (MPEP 503) <small>(Should be specifically itemized)</small> 13. <input checked="" type="checkbox"/> * Small Entity Statement(s) filed in prior application, Status still proper and desired (PTO/SB/09-12) 14. <input type="checkbox"/> Certified Copy of Priority Document(s) (if foreign priority is claimed) 15. <input type="checkbox"/> Other: | |

*** NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).**

| |
|---|
| 16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment: <input type="checkbox"/> Continuation <input type="checkbox"/> Divisional <input type="checkbox"/> Continuation-in-part (CIP) of prior application No: _____ Prior application information: Examiner _____ Group / Art Unit: _____ For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts. |
|---|

| | | | | | |
|--|---------------------------------|-----------|--------------|----------|--------------|
| 17. CORRESPONDENCE ADDRESS | | | | | |
| <input type="checkbox"/> Customer Number or Bar Code Label (Insert Customer No. or Attach bar code label here) or <input checked="" type="checkbox"/> Correspondence address below | | | | | |
| Name | LAW OFFICE OF KENNETH C. BROOKS | | | | |
| Address | P.O. Box 10417 | | | | |
| City | Austin | State | Texas | Zip Code | 78766-1417 |
| Country | United States | Telephone | 512 527-0104 | Fax | 512-527-0107 |

| | | | |
|-------------------|--------------------------|-----------------------------------|-----------------|
| Name (Print/Type) | Kenneth C. Brooks | Registration No. (Attorney/Agent) | 38,393 |
| Signature | <i>Kenneth C. Brooks</i> | Date | August 25, 2000 |

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

+

PTO
09/64887
08/25/00

**STATEMENT CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) & 1.27(b))--INDEPENDENT INVENTOR**

Docket Number (Optional)

MYS-00-02-02

Applicant, Patentee, or Identifier: Robert Mays, Jr.

Application or Patent No.: Unassigned

Filed or Issued: Herewith

Title: Shared Multi-Channel Paralle Optical Interface

As a below named inventor, I hereby state that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees to the Patent and Trademark Office described in:

- ☒ the specification filed herewith with title as listed above.
☐ the application identified above.
☐ the patent identified above.

I have not assigned, granted, conveyed, or licensed, and am under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention to any person who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern, or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

- ☐ No such person, concern, or organization exists.
☒ Each such person, concern, or organization is listed below.

RDM Foundation, Inc. (a Texas Corporation)

Separate statements are required from each named person, concern, or organization having rights to the invention stating their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

Robert Mays, Jr.

NAME OF INVENTOR

NAME OF INVENTOR

NAME OF INVENTOR

Signature of inventor

Signature of inventor

Signature of inventor

Date

Date

Date

**STATEMENT CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) & 1.27(c))—SMALL BUSINESS CONCERN**

Docket Number (Optional)
MYS-00-02-02

Applicant, Patentee, or Identifier: Robert Mays, Jr.

Application or Patent No.: Unassigned

Filed or Issued: Herewith

Title: SHARED MULTI-CHANNEL PARALLEL OPTICAL INTERFACE

I hereby state that I am

- ☐ the owner of the small business concern identified below:
☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN RDM Foundation, Inc. (a Texas Corporation)

ADDRESS OF SMALL BUSINESS CONCERN 10707 Pinehurst Drive
Austin, Texas 78747

I hereby state that the above identified small business concern qualifies as a small business concern as defined in 13 CFR Part 121 for purposes of paying reduced fees to the United States Patent and Trademark Office. Questions related to size standards for a small business concern may be directed to: Small Business Administration, Size Standards Staff, 409 Third Street, SW, Washington, DC 20416.

I hereby state that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in:

- ☒ the specification filed herewith with title as listed above.
☐ the application identified above.
☐ the patent identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern, or organization having rights in the invention must file separate statements as to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

- Each person, concern, or organization having any rights in the invention is listed below:
☒ no such person, concern, or organization exists.
☐ each such person, concern, or organization is listed below.

Separate statements are required from each named person, concern or organization having rights to the invention stating their status as small entities. (37 CFR 1.27)

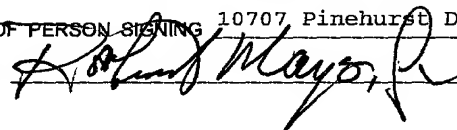
I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

NAME OF PERSON SIGNING Robert Mays, Jr.

TITLE OF PERSON IF OTHER THAN OWNER Chief Executive Officer

ADDRESS OF PERSON SIGNING 10707 Pinehurst Drive, Austin, Texas 78747

SIGNATURE



DATE

8/25/00

PATENT APPLICATION
SHARED MULTI-CHANNEL PARALLEL OPTICAL INTERFACE

Inventors:

Robert Mays, Jr.
A Citizen of the United States of America,
10707 PineHurst Drive.
Austin, Texas 78747

Assignee:

RDM Foundation, Inc.
10707 PineHurst Drive.
Austin, Texas 78747
A Texas Corporation

Entity: Small

LAW OFFICE OF KENNETH C.BROOKS
P.O. Box 10417
Austin, Texas 78766-1417
Tel: (512)-527-0104

SHARED MULTI-CHANNEL PARALLEL OPTICAL INTERFACE

BACKGROUND OF THE INVENTION

The present invention relates to an optical free space interconnect of circuitry.

5 Particularly, the present invention concerns optical interconnection employed in computers.

One of the current approaches to increasing computational and control power is to link multiple low cost, distributed processors together. In this manner, the cost associated with a single processor capable of the similar computational efficiency may be avoided.

10 Currently the distributed processing is achieved by employing high-speed data links using conventional wire and connector technology, referred to herein as "hardwired technology". Specifically, the high-speed data links facilitate data communication between processor nodes and other dedicated component-to-component and/or board-to-board applications as processor speeds increase. As processor speeds increase, however,
15 the present data-links will result in data transfer bottlenecks, due to the limited data transfer rate the same may provide. Moreover, data link reliability may be compromised as the number of wires employed in the data link increases.

To improve the operational characteristics of the aforementioned data links, advancements in optical communication systems have been employed to replace the
20 conventional the hardwired technology. A well-known example includes the replacement of conventional copper wires used for telephony with optical dielectric wave guides commonly know as optical fibers. This has generated a need for improvement methodologies to interconnect the optical fibers together or with other optical devices such as light sources, light detectors, and the like. To that end, the prior art is replete
25 with improved techniques for interconnecting optical components.

United States patent number 4,057,319 to Ash et al. discloses such a technique. Specifically, the patent to Ash et al. discloses an optical system in which individual connections are made involving the passage of light between a specific device in one array of optical devices and a specific device in another array of optical devices via a
30 phase hologram plate of the transmission type fixed relative to each array.

United States patent number 5,140,657 to Thylen discloses a device for optically coupling an optical fiber, forming part of an optical communication system, to an optical

semiconductor laser amplifier. Specifically, the semiconductor laser amplifier has an input facet and an output facet, and the optical fiber has an end surface arranged opposite to at least one of the facets. A diffraction optics element is disposed between the end surface of the fiber and the surface of the facet in order to adapt the nearfield of the fiber end to the nearfield of the facet surface while filtering the same to reduce spontaneous emission noise. The diffraction optics element is described as being a phase hologram.

United States patent 6,072,579 to Funato discloses an optical pickup apparatus that includes first and second light sources that selectively emit one of first and second light beams. The first and second light beams are different in wavelength and are suitable for accessing first and second optical disks respectively. A coupling lens converts a corresponding one of the first and second light beams into a collimated beam. An objective lens forms a light spot on a corresponding one of the first and second optical disks by focusing the collimated beam. A holographic optical element receives a reflection beam of the light spot from one of the first and second optical disks and provides holographic effects on the reflection beam so as to diffract the reflection beam in predetermined diffracting directions depending on the wavelength of the reflection beam. A photo detector receives the reflection beam from the holographic optical element at light receiving areas and outputs signals indicative of respective intensities of the received reflection beam at the light receiving areas, so that a focusing error signal and a tracking error signal are generated based on the signals. A drawback with the aforementioned optical interconnect systems is that each coupling device requires precise alignment of the optical elements to achieve efficient coupling of optical energy.

What is needed, therefore, is an optical coupling technique that decreases the alignment tolerances of the various optical devices between which optical energy is coupled.

SUMMARY OF THE INVENTION

Provided is an optical communication system and method that features concurrently refracting and filtering, employing a holographic transform, optical energy to impinge upon an optical detector with unwanted characteristics of the optical energy being removed. To that end, the system includes a source of optical energy to direct optical energy along a path, an optical detector disposed in the path, and an optical

apparatus. The optical apparatus has a spherical surface and a holographic transform function, with the optical apparatus being disposed to filter the optical energy in accordance with properties of the holographic transform function to remove optical energy having unwanted characteristics, defining transformed optical energy, and refract the transformed energy in accordance with properties of the spherical surface to impinge upon a detector.

In another embodiment, the system includes an array of optical transmitters to generate optical energy to propagate along a plurality of axes and an array of optical receivers, each of which is positioned to sense optical energy propagating along one of the plurality of optical axes. The optical apparatus includes first and second arrays of refractory lens. Each of the lens of the first array is disposed in one of the plurality of axes and has a first holographic transform function disposed thereon to filter from the optical energy unwanted characteristics. The first holographic transform function associated with a subgroup of the lens of the first array, defines a transfer function that differs from the first holographic transform function associated with the remaining lens of the first array of lenses. Each of the lenses of the second array is disposed between the first array of lenses and the array of optical receivers to collect optical energy propagating along the one of the plurality of optical axes. A subset of the lenses of the second array having a spherical surface with a second holographic transform function disposed on the second surface that matches the transfer function. A method is also disclosed, the functions of which are carried out by the aforementioned systems.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a simplified plan view of an optical communication system in accordance with the present invention;

Fig. 2 is a cross-sectional view of a lens employed in the optical communication system shown above in Fig. 1, in accordance with the present invention;

Fig. 3 is a cross-sectional view of the lens shown above in Fig. 2 in accordance with an alternate embodiment of the present invention;

Fig. 4 is a cross-sectional view of the lens shown above in Fig. 2 in accordance with a second alternate embodiment of the present invention;

Fig. 5 is perspective view of the optical communication system shown above in Fig. 1, in accordance with an alternate embodiment;

Fig. 6 is perspective view of an array of the lenses fabricated on a photo-sheet shown above in Fig. 5;

5 Fig. 7 is a cross-sectional plan view of the optical communication system shown above in Fig. 5, in accordance with the present invention;

Fig. 8 is a cross-sectional plan view of the optical communication system shown above in Fig. 7, in accordance with an alternate embodiment of the present invention;

10 Fig. 9 is a simplified plan view showing an apparatus for fabricating the lenses shown above in Figs. 2-4 and 6, in accordance with the present invention;

Fig. 10 is a cross-sectional view of a substrate on which the lenses discussed above with respect to Figs. 2-4 and 6 are fabricated;

15 Fig. 11 is a cross-sectional view of the substrate, shown above in Fig. 10, under going processing showing a photoresist layer disposed thereon;

Fig. 12 is a cross-sectional view of the substrate, shown above in Fig. 11, under going processing showing a photoresist layer being patterned;

Fig. 13 is a cross-sectional view of the substrate, shown above in Fig. 12, under going processing after a first etch step; and

20 Fig. 14 is a cross-sectional view of the substrate, shown above in Fig. 13, under going processing after a second etch step.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1, shown is an optical communication system 10 including a source of optical energy 12, an optical detector 14 in data communication with the source
25 of optical energy 12, with an optical apparatus 16 disposed therebetween. The source 12 directs optical energy 18 along a path 20 in which the optical detector 14 lies. The optical apparatus 16 is disposed between the source 12 and the optical detector 14. Having both a refractory function and a holographic transform function, the optical apparatus 16 concurrently filters and refracts the optical energy propagating therethrough.
30 In this manner, the optical apparatus 16 removes unwanted characteristics from the

optical energy passing therethrough causing the same to impinging upon the optical detector 14.

The unwanted characteristics that may be removed from the optical energy 18 includes wavelength or polarization information. Specifically, the optical apparatus 16 is
5 a refractory lens having a bulk hologram recorded therein that defines the transform function. The bulk hologram facilitates characterizing the optical energy 18 to have desired characteristics that may improve detection, by the optical detector 14, of information contained in the optical energy 18. For example, the transform function may allow a specific wavelength to pass through the lens, diffracting all other wavelengths to
10 deflect away from the optical detector 14. Alternatively, the transform function may allow only a certain polarization of the optical energy 18 to propagate therethrough, diffracting all other polarizations away from the optical detector 14.

The refractory function of the optical apparatus 16 facilitates impingement of the optical energy 18 onto the optical detector 14. In this manner, the precise alignment of
15 the optical detector 14 with respect to the source 12 and, therefore, the path 20 may be relaxed.

Referring to Fig. 2, the optical apparatus 16 is a lens 22 having an arcuate surface 24, e.g., cylindrical, spherical and the like with a bulk holographic transform function formed therein. The bulk holographic transform function is shown graphically as
20 periodic lines 26 for simplicity. The bulk holographic transform function 26 is recorded in substantially the entire volume of the lens 22 through which optical energy will propagate. The transform function 26 is a periodic arrangement of the space-charge field of the material from which the lens 22 is fabricated. To that end, the lens 22 may be formed from any suitable photo-responsive material, such as silver halide or other
25 photopolymers. In this manner, the lens 22 and the bulk holographic transform function 26 is integrally formed in a manner described more fully below. Although the surface 28 of the lens 22 disposed opposite to the spherical arcuate surface 24 is shown as being planar, the surface 28 may also be arcuate as shown in surface 128 of lens 122 in Fig. 3.

Referring to both Figs. 2 and 4, were it desired to further control the shape of
30 optical energy propagating through lens 22, a lens 222 may be formed with a fresnel lens 228 disposed opposite to the spherical surface 224. In this manner, substantially all of

the optical energy propagating through the lens 222 may be focused to differing points, depending upon the wavelength of optical energy propagating therethrough. To that end, the fresnel lens 228 includes a plurality of concentric grooves, shown as recesses 228a 228b and 228c that are radially symmetrically disposed about a common axis 230. Thus, the lens 222 may have three optical functions integrally formed in a common element, when providing the bulk holographic transform function 226 therein.

Referring to Fig. 5 in another embodiment, the optical communication system 310 includes an array 312 of optical transmitters, shown generally as 312a-312p and an array 314 of optical detectors, shown generally as 314a -412p. The optical transmitters 312a-312p generate optical energy to propagate along a plurality of axes, and the optical receivers 314a-314p are positioned to sense optical energy propagating along one of the plurality of optical axes. Specifically, the array 312 is an (XxY) array of semiconductor lasers that produce a beam that may be modulated to contain information. The array 314 may comprise of virtually any optical detector known, such a charged coupled devices (CCD) or charge injection detectors (CID). In the present example, the array 314 comprises of CIDs arranged in an (MxN) array of discrete elements. The optical beam from the each of the individual emitters 312a-312p may expand to impinge upon each of the detectors 314a -412p of the array 314 if desired. Alternatively, the optical beam from each of the individual emitters 312a-312p may be focused to impinge upon any subportion of the detectors 314a -314p of the array 314. In this fashion, a beam sensed by one of the detectors 314a-314p of the array 314 may differ from the beam sensed upon the remaining detectors 314a-314p of the array 314. To control the wavefront of the optical energy produced by the transmitters 312a-312p, the optical apparatus 16, discussed above with respect to Figs 1-4 may be employed as an array of the lenses 22, shown more clearly in Fig. 6 as array 400.

Specifically, referring to Figs. 5 and 7, the individual lenses 422 of the array are arranged to be at the same pitch and sizing of the array 312. The numerical aperture of each of the lenses 422 of the array 400 is of sufficient size to collect substantially all of the optical energy produced by the transmitters 312a-312p corresponding thereto. In one example, the array 400 is attached to the array 312 with each lens resting adjacent to one of the transmitters 312a-312p. To provide the necessary functions, each of the lenses of

the array 400 may be fabricated to include the features mentioned above in Figs. 2-4. As a result, each of the lenses 422 of the array may be formed to having functional characteristics that differ from the remaining lenses 422 of the array. In this manner, each beam produced by the array 312 may be provided with a unique wavelength, polarization or both. This facilitates reducing cross-talk and improving signal-to-noise ratio in the optical communication system 310.

Specifically, the optical apparatus 316 may include an additional array of lenses 400b that match the pitch of the individual detectors 314a-314p of the array 314, shown more clearly in Fig. 8. The lens may be fabricated to provide the same features as discussed above with respect to array 400, shown in Fig. 6. Referring to Figs. 5, 6 and 8 each of the transmitters 312a-312p of the array 312 would then be uniquely associated to communicate with only one of the detectors 314a-314p of the array 314. In this manner, the transmitter 312a-312p of the array 312 that is in data communication with one of the one of the detectors 314a-314p of the array 314 would differ from the transmitters 312a-312p in data communication with remaining detectors 314a-314p of the array 314. This transmitter detector pair that were in optical communication is achieved by having the properties of the lens 422 in array 400 match the properties of the lens 422b in array 400b. It should be understood, however that one of the transmitters 312a-312p may be in data communication with any number of the detectors 314a-314p by multiple lenses 422b matching the properties of one of the lenses 422. Similarly, one of the multiple transmitters 312a-312p may be in optical communication with one or more of the detectors 314a-314p by appropriately matching the lenses 422 to the lenses 422b.

In one example, superior performance was found by having the array 314 sectioned into (mxn) bins, with each bin corresponding to a particular polarization and/or wavelength that matched a particular polarization and/or wavelength corresponding to a transmitter 312a-312p. Thus, were a beam from one or more of the transmitters 312a-312p to flood the entire (MxN) array 314 or multiple (mxn) bins, only the appropriate detectors 314a-314p sense information with a very high signal-to-noise ratio and discrimination capability. It will be noted that the (mxn) bins can also be effectively comprised of a single sensing pixel (element) to exactly match the (XxY) array.

Additional beam-sensor discrimination may be achieved by employing transmitters 312a-312p having different wavelengths or by incorporating up-conversion processes that include optical coatings applied to the individual transmitters 312a-312p or made integral therewith. One such up-conversion process is described by F.E. Auzel in
5 "Materials and Devices Using Double-Pumped Phosphors With Energy Transfer", Proc. of IEEE, vol. 61. no. 6, June 1973.

Referring to Figs. 2, 8 and 9, the system 500 employed to fabricate the lens 22 and the lens arrays 400 and 400b includes a beam source 502 that directs a beam 504a into wave manipulation optics 506 such as a $\frac{1}{4}$ waveplate 508 so that the beam 504b
10 is circularly polarized. The beam 504b impinges upon polarizer 510 so that the beam 504c propagating therethrough is linearly polarized. The beam 504c impinges upon a Faraday rotator 512 that changes birefringence properties to selectively filter unwanted polarizations from the beam 504c. In this manner, the beam 504d egressing from the rotator 512 is linearly polarized. The beam 504d impinges upon a beam splitter 514 that
15 directs a first subportion 504e of beam 504d onto a planar mirror 516. A second subportion 504f of the beam 504d pass through the splitter 514. The first and second subportions 504e and 504f intersect at region 520 forming an optical interference pattern that is unique in both time and space. A photosensitive sheet 522 is disposed in the region so as to be exposed to the optical interference pattern. The interference pattern
20 permeates the photosensitive sheet 522 and modulates the refractive index and charge distribution throughout the volume thereof. The modulation that is induced throughout the volume of the photosensitive sheet 522 is in strict accordance with the modulation properties of the first and second subportions 504e and 504f. Depending upon the photosensitive material employed, the holographic transform function may be set via
25 thermal baking.

Referring to Figs. 9 and 10, an arcuate surface is formed in the photosensitive sheet 522 by adhering a photosensitive layer 600 to a sacrificial support 602, such as glass, plastic and the like to form a photosensitive substrate 604. Typically, the photosensitive layer 600 is tens of microns thick. As shown in Fig. 11, a photo resist
30 layer 606 is deposited onto the photosensitive layer 600 and then is patterned to leave predetermined areas exposed, shown as 608 in Fig. 12, defining a patterned substrate 610.

Located between the exposed areas 608 are photo resist islands 612. The patterned substrate 610 is exposed to a light source, such as ultraviolet light. This ultraviolet light darkens the volume of the photo resist layer 600 that is coextensive with the exposed areas 608 being darkened, i.e., become opaque to optical energy. The volume of the photosensitive layer 600 that are coextensive with the photo resist islands 612 are not darkened by the ultraviolet light, i.e., remaining transparent to optical energy. Thereafter, the photo resist islands 612 are removed using standard etch techniques, leaving etched substrate 614, shown in Fig. 13.

The etched substrate 614 has two arcuate regions 616 that are located in areas of the photosensitive layer 600 disposed adjacent to the islands 612, shown in Fig. 12. The arcuate regions 616 of Fig. 13 result from the difference in exposure time to the etch process of the differing regions of the photosensitive layer 600.

Referring to Figs. 8 and 14, a subsequent etch process is performed to form array 400. During this etch process the support is removed as well as nearly 50% of the photosensitive layer 600 to form a very thin array. The array 400 is then placed in the apparatus 500 and the bulk holographic transform functions are recorded in the arcuate regions 616 that define the lenses 422, as discussed above. A fresnel lens may also be formed on the lenses 422 of the array using conventional semiconductor techniques. Thereafter, the lenses may be segmented from the photo resistive sheet or MxN subarrays of lenses may be segmented therefrom.

Although the invention has been described in terms of specific embodiments, one skilled in the art will recognize that various changes to the invention may be performed, and are meant to be included herein. For example, instead of forming the arcuate regions 616 using standard etch techniques, the same may be formed by exposing the substrate 610, shown in Fig. 12, to thermal energy. In one example, the substrate 610 is convectionally heated, and the photo resist layer 606 is patterned to control the regions of the photosensitive layer 600 that may expand. In another example, the photosensitive layer is heated by conduction employing laser ablation/shaping. Specifically, a laser beam impinges upon areas of the photosensitive layer 600 where lens are to be formed. The thermal energy from the laser beam causes the photosensitive layer 600 to bubble, forming arcuate regions 616 thereon shown in Fig. 13. Therefore, the

scope of the invention should not be based upon the foregoing description. Rather, the scope of the invention should be determined based upon the claims recited herein, including the full scope of equivalents thereof.

WHAT IS CLAIMED IS:

- 1 1. An optical communication system comprising:
2 a source of optical energy to propagate optical energy along an optical path;
3 a detector positioned in the optical path;
4 an optical system having an arcuate surface and a holographic transform function,
5 with the optical element being disposed to filter the optical energy in accordance with
6 properties of the holographic transform function to remove optical energy having
7 unwanted characteristics, defining transformed optical energy, and refract the
8 transformed energy in accordance with properties of the spherical surface to impinge
9 upon the detector.
- 1 2. The system as recited in claim 1 wherein the characteristics are selected
2 from a group consisting essentially of polarization, wavelength and phase.
- 1 3. The system as recited in claim 1 wherein the source of optical energy
2 includes an array of optical transmitters to generate optical energy to propagate along a
3 plurality of axes and the detector includes an array of optical receivers, each of which is
4 positioned to sense optical energy propagating along one of the plurality of optical axes
5 and the optical system includes an array of lenses, each of which is disposed in one of the
6 plurality of axes and includes the arcuate surface with the holographic transform being
7 disposed within a volume of the array of lenses.
- 1 4. The system as recited in claim 1 wherein the source of optical energy
2 includes an array of optical transmitters to generate optical energy to propagate along a
3 plurality of axes and the detector includes an array of optical receivers, each of which is
4 positioned to sense optical energy propagating along one of the plurality of optical axes
5 and the optical system including a plurality of lenses having the arcuate surface with
6 holographic transform function being disposed within a volume thereof, with the plurality
7 of lenses being arranged in first and second arrays, the first array being disposed between
8 the array of optical transmitters and the array of optical receivers and the second array
9 being disposed between the first array and the optical receivers.

1 5. The system as recited in claim 4 wherein the holographic transform
2 function associated with a subgroup of the lenses of the first array, defining a transfer
3 function, differs from the holographic transform function associated with the remaining
4 lenses of the first array of lenses, and the holographic transform function associated with
5 a subset of the lenses of the second array matches the transfer function.

1 6. The optical communication system as recited in claim 1 wherein the
2 optical element has opposed sides with a spherical surface being positioned on one of the
3 opposed sides and a planar surface being disposed on the remaining side of the opposed
4 sides with the holographic transform function being disposed within a volume of the lens
5 between the spherical and the planar surfaces.

1 7. The optical communication system as recited in claim 1 wherein the
2 optical element has opposed sides with a cylindrical surface being positioned on one of
3 the opposed sides and a planar surface being disposed on the remaining side of the
4 opposed sides, with the holographic transform function being disposed within a volume
5 of the lens between the cylindrical and the planar surfaces.

1 8. The optical communication system as recited in claim 1 wherein the
2 optical element has opposed sides with a spherical surface being positioned on one of the
3 opposed sides and a rotary symmetric arrangement of grooves defining a fresnel lens
4 being disposed on the remaining side of the opposed sides with the holographic transform
5 function being disposed within a volume of the lens between the spherical surface and the
6 fresnel lens.

1 9. The optical communication system as recited in claim 1 wherein the
2 optical element has opposed sides with a cylindrical surface being positioned on one of
3 the opposed sides and a rotary symmetric arrangement of grooves defining a fresnel lens
4 being disposed on the remaining side of the opposed sides, with the holographic
5 transform function being disposed within a volume of the lens between the cylindrical
6 surface and the fresnel lens.

1 10. The optical communication system as recited in claim 1 wherein the
2 optical element has opposed side, both of which are arcuate, with the holographic

3 transform function being disposed within a volume of the lens between the opposed
4 arcuate surface.

1 11. An optical communication system comprising:

2 an array of optical transmitters to generate optical energy to propagate along a
3 plurality of axes;

4 an array of optical receivers, each of which is positioned to sense optical energy
5 propagating along one of the plurality of optical axes;

6 a first array of refractory lenses, each of which is disposed in one of the plurality
7 of axes and has a first holographic transform function disposed therein to filter from the
8 optical energy unwanted characteristics, with the first holographic transform function
9 associated with a subgroup of the lens of the first array, defining a transfer function,
10 differing from the first holographic transform function associated with the remaining lens
11 of the first array of lenses; and

12 a second array of refractory lenses, each of which is disposed between the first
13 array of lenses and the array of optical receivers to collect optical energy propagating
14 along the one of the plurality of optical axes, with a subset of the lenses of the second
15 array having a second holographic transform function disposed therein that matches the
16 transfer function.

1 12. The optical communication system as recited in claim 11 wherein the
2 lenses of the first and second array include a rotary symmetric arrangement of grooves
3 defining a fresnel lens.

1 13. The optical communication system as recited in claim 11 wherein the
2 lenses of the first and second arrays have a spherical surface and an additional surface
3 disposed opposite to the spherical surface, with a fresnel lens being disposed on the
4 additional surface.

1 14. The optical communication system as recited in claim 11 wherein the
2 lenses of the first and second arrays have a cylindrical surface and an additional surface
3 disposed opposite to the cylindrical surface, with a fresnel lens being disposed on the
4 additional surface.

1 15. The system as recited in claim 11 wherein the first holographic transform
2 function is disposed within a volume of each of the lenses of the first and array and the
3 second holographic transform function is disposed throughout a volume of each of the
4 lenses of the second array.

1 16. The system as recited in claim 11 wherein the characteristics are selected
2 from the group consisting essentially of polarization, wavelength and phase.

1 17. An optical communication system comprising:
2 an array of optical transmitters to generate optical energy to propagate along a
3 plurality of axes;
4 an array of optical receivers, each of which is positioned to sense optical energy
5 propagating along one of the plurality of optical axes;
6 means disposed between the array of optical transmitters and the array of optic
7 receivers, for concurrently filtering the optical energy to remove unwanted characteristics
8 therefrom and refracting the optical energy to impinge upon the array of optical receivers.

1 18. The system as recited in claim 17 wherein the concurrently filtering and
2 refracting means further includes means for placing one of the optical transmitters of the
3 array of optical transmitters, defining a first transmitter, in data communication with one
4 of the optical receivers of the array of optical receivers, with the remaining optical
5 receivers of the array of optical receivers being in data communication with optical
6 transmitters of the array of optical transmitters that differ from the first optical
7 transmitter.

1 19. The system as recited in claim 17 wherein the concurrently filtering and
2 refracting means further includes means for placing one of the optical receivers of the
3 array of optical receivers, defining a first receiver, in data communication with one of the
4 optical transmitters of the array of optical transmitters, with the remaining optical
5 transmitters of the array of optical transmitters being in data communication with optical
6 receivers of the array of optical receivers that differ from the first optical receiver.

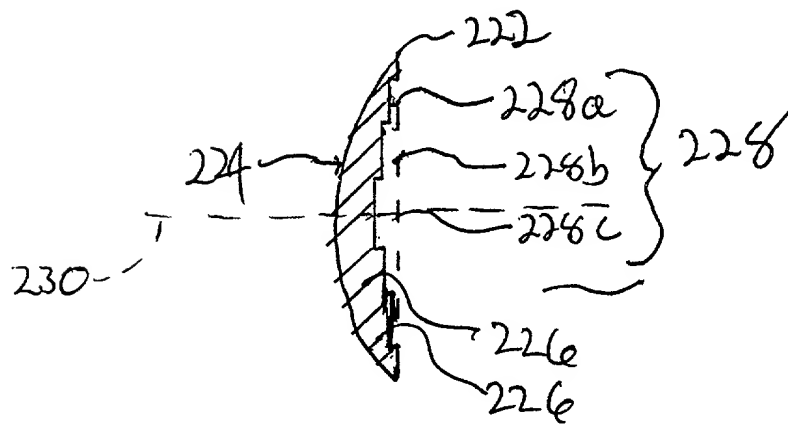
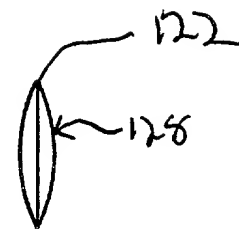
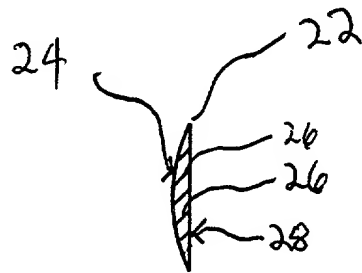
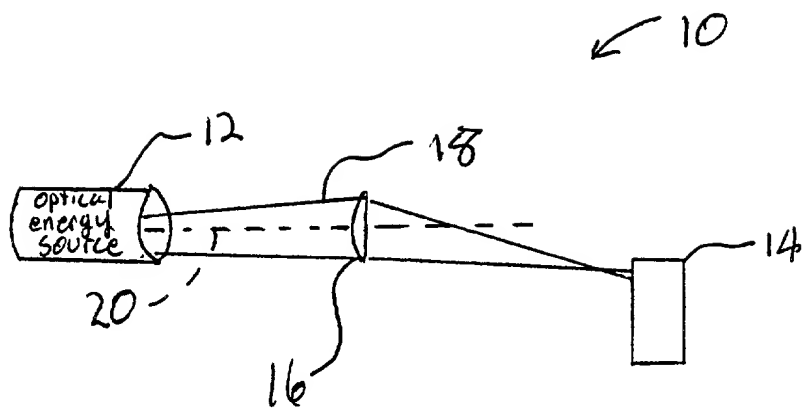
1

1 20. The system as recited in claim 17 wherein the concurrently filtering and
2 refracting means further includes means for placing the array of optical receivers in data
3 communication with the array of optical transmitters, defining a plurality of
4 transmitter/receiver pairs, with the transmitter and receiver of each of the plurality of
5 transmitter/receiver pairs differing from the transmitter and receiver associated with the
6 remaining transmitter/receiver pair of the plurality of transmitter/receiver pairs.

SHARED MULTI-CHANNEL PARALLEL OPTICAL INTERFACE

ABSTRACT OF THE DISCLOSURE

- 5 An optical communication method and system that features concurrently refracting and filtering, employing a holographic transform function, optical energy to impinge upon an optical detector with unwanted characteristics of the optical energy being removed. To that end, the system includes a source of optical energy to direct optical energy along a path, an optical detector disposed in the path, and an optical
- 10 apparatus. The optical apparatus includes a lens having an arcuate surface and a holographic transform function recorded throughout the volume of the lens.



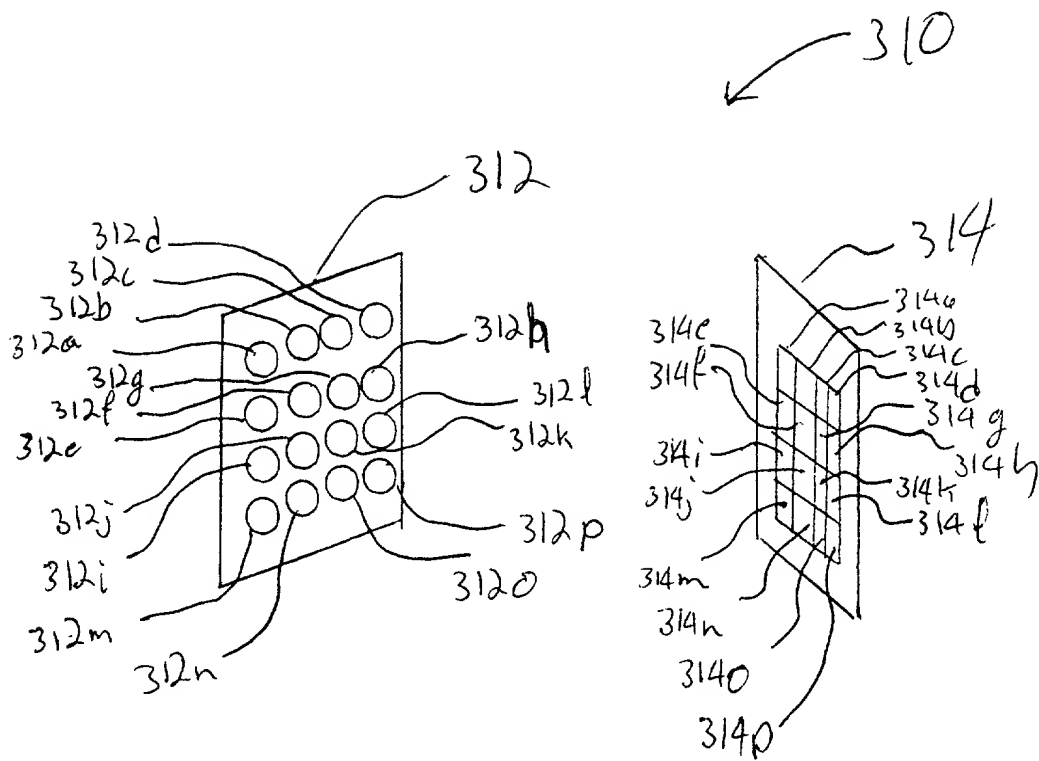
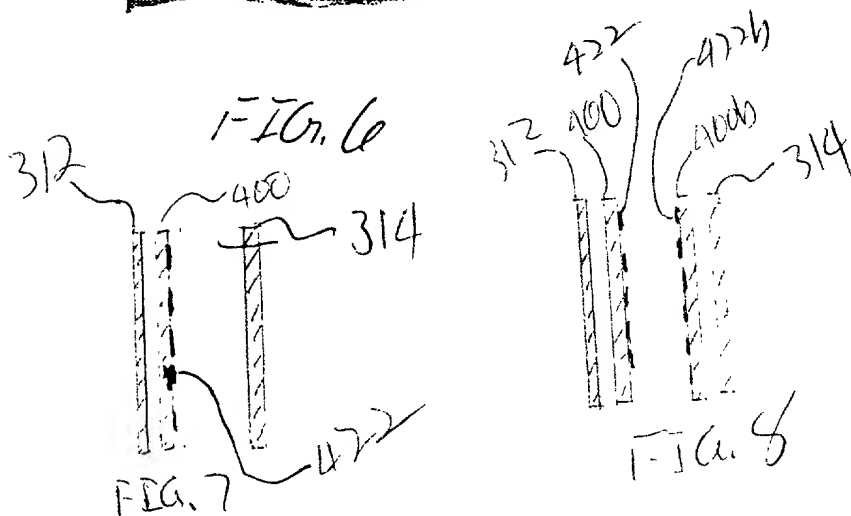
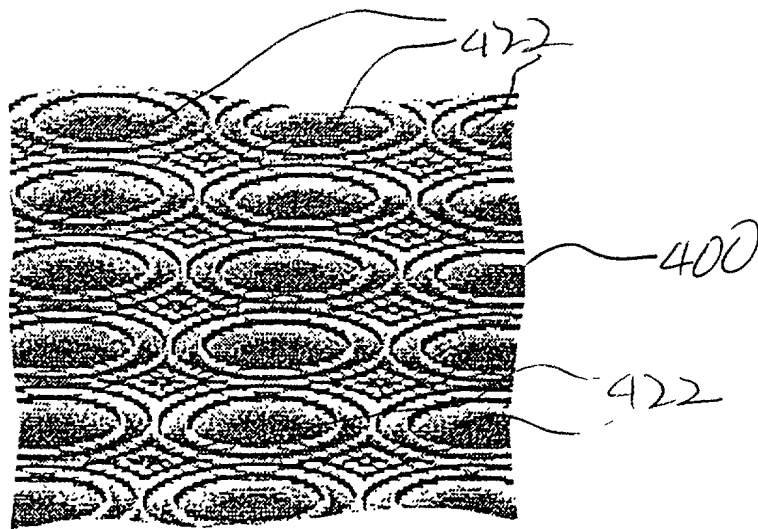
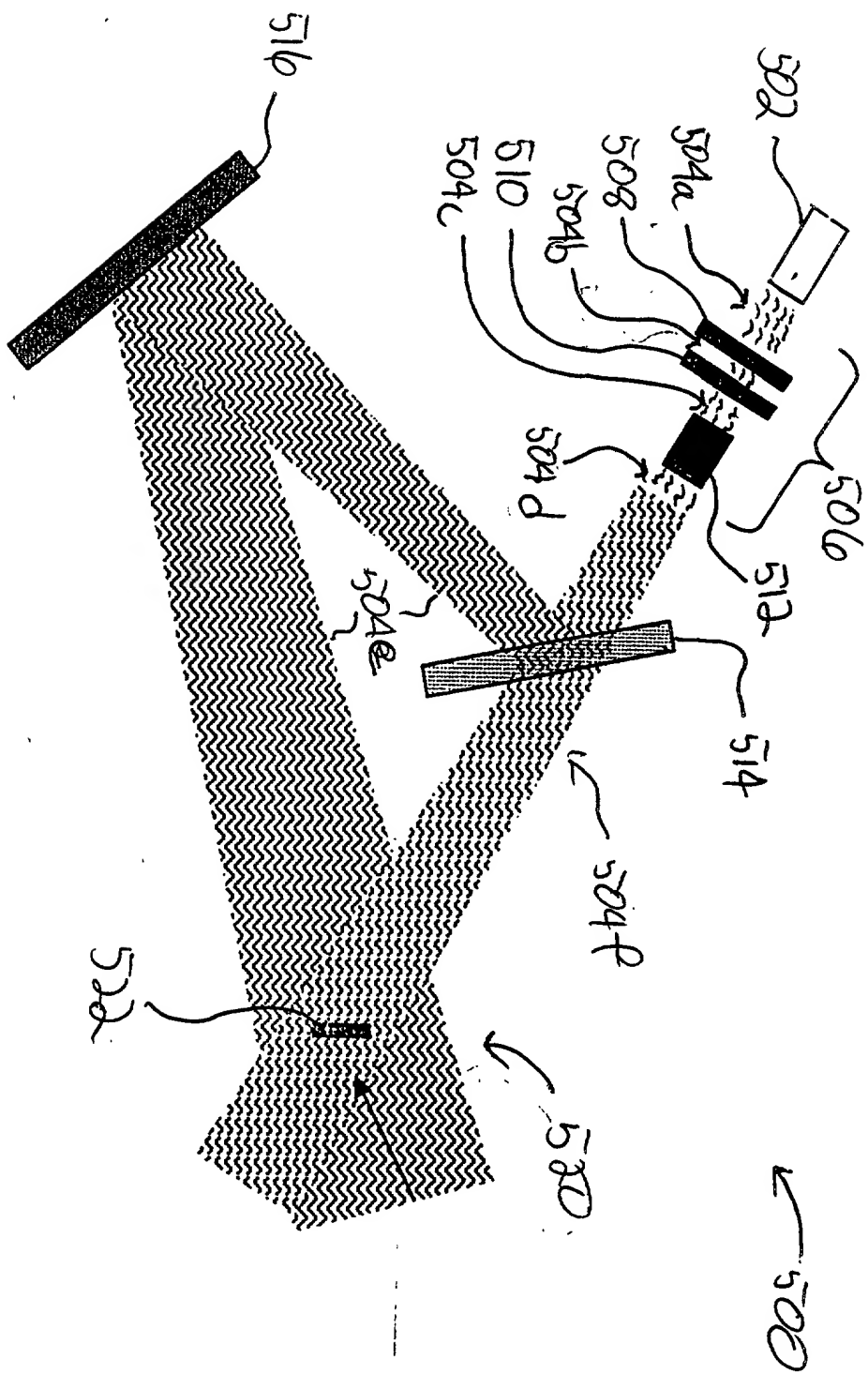


FIG. 5





09644649.052500

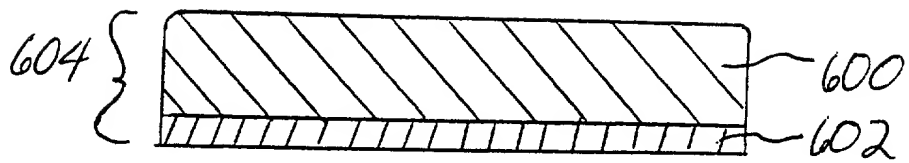


FIG. 10

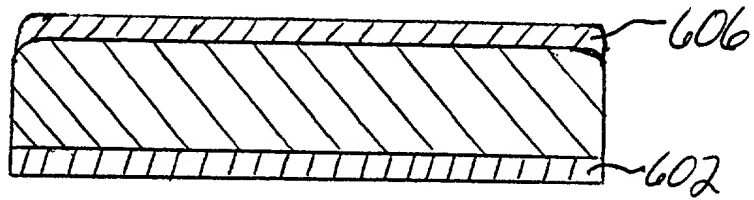


FIG. 11

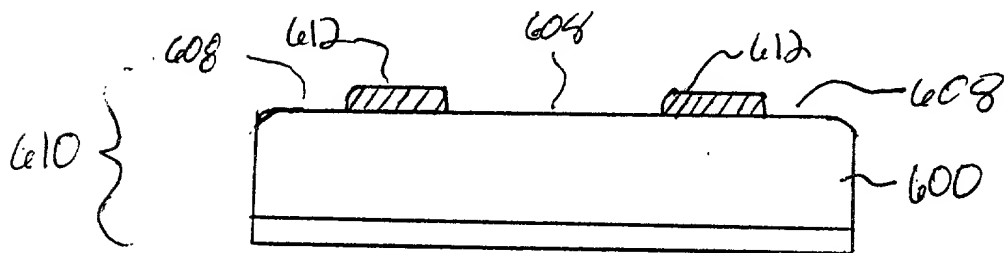


FIG. 12

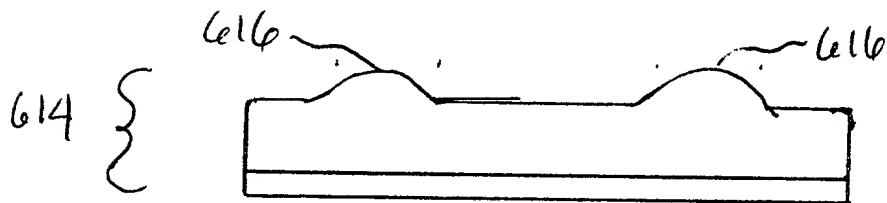


FIG. 13

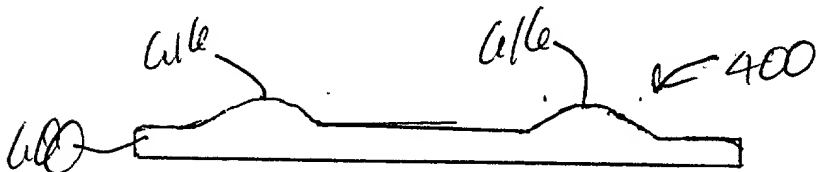


FIG. 14

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

This declaration is of the following type:

- ☒ original
- ☐ divisional
- ☐ continuation
- ☐ continuation-in-part

ROBERT MAYS, JR.
10707 PINEHURST DRIVE
AUSTIN, TEXAS 78747
CITIZEN OF UNITED STATES

My residence, post office address and citizenship are as stated below next to my name. I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SHARED MULTI-CHANNEL PARALLEL OPTICAL INTERFACE

SPECIFICATION IDENTIFICATION

The specification of which:

- ☒ is attached hereto
- ☐ was filed on {Filing Date}, under Serial No. {Serial No.}, executed on even date herewith; or [] Express Mail No.(as Serial No. not yet known) and was amended on _____ (if applicable)
- ☐ was described and claimed in PCT International Application No. _____ filed on _____ and as amended under PCT Article 19 on _____.

ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, 1.56,

and which is material to the examination of this application; namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent, and

- ☐ In compliance with this duty there is attached an Information Disclosure Statement in accordance with 37 CFR 1.98.

PRIORITY CLAIM (35 U.S.C. §119)

I hereby claim foreign priority benefits under Title 35, United States Code, §119, of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other

than the United States of America or of any United States Provisional Application(s) listed below, and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

- ☐ No such applications have been filed.
☐ Such applications have been filed as follows:

A. Prior foreign/PCT/provisional application(s) filed within 12 mos. (6 mos. for design) prior to this application, and any priority claims under 35 U.S.C. § 119

| <u>Country/PCT</u> | <u>Application No</u> | <u>Date Filed</u> | <u>Priority Claimed</u> |
|--------------------|-----------------------|-------------------|--|
| | | | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| | | | <input type="checkbox"/> Yes <input type="checkbox"/> No |

B. All foreign application(s), if any, filed more than 12 mos. (6 mos for design) prior to this U.S. application

Country:
 Application No:
 Filing date:

PRIORITY CLAIM (35 U.S.C. §120)

I hereby claim the benefit under Title 35, United States Code, § 120, of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information that is material to the examination of this application (namely, information where there is substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application.

- ☐ No such applications have been filed
☐ Such applications have been filed, as follows:

| <u>Serial No.</u> | <u>Filing Date</u> | <u>Status</u> |
|-------------------|--------------------|--|
| | | <u>Patented Pending</u> <u>Abandoned</u> |

POWER OF ATTORNEY

I hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

| | |
|---------------------------------|-----------------------------------|
| Kenneth C. Brooks | Registration No. 38,393 |
| Send correspondence to: | Direct telephone calls to: |
| Law Office of Kenneth C. Brooks | (512) 527-0104 |
| P.O. Box 10417 | |
| Austin, Texas 78766-1417 | |

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and, further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Sec. 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

Full name of sole inventor: Robert Mays, Jr.

Inventor's signature: _____

Residence: _____

Post Office Address: _____

Austin, Texas

10707 Pinehurst Drive

Austin, Texas

U.S.A.

Date: _____

8/25/00

(Declaration ends with this page)